Performance of Texture Based Filters For The Extraction of Features From The Sateliite Imageries Using Confusion Matrix and Artificial Neural Networks

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Abstract. The Artificial Neural Network (ANN) and confusion matrix techniques have been used to study the performance of different texture based filters such as STD filter and Range filter, Entropy filter, for extracting features from high resolution satellite imageries. Texture analysis attempts to quantify intuitive qualities described by terms such as rough, smooth, silky or bumpy as a function of the spatial variation in pixel intensities. In the first step texture filters are used to obtain the textured image of a satellite rural scene which is later subjected to the ANN procedures to obtain the mean error plots and confusion matrix. The results show that the entropy filters are more efficient for extracting the features present in satellite imageries. The important features extracted with high probability of occurrence include are vegetation, water bodies and other features such as housing etc present in the satellite rural image. The results of the analysis are presented and discussed in the paper.

Keywords: Texture, Artificial Neural Network, Entropy filter, Range filter, STD filter, confusion matrix

1. Introduction

Image filtering is useful for many applications like smoothing, sharpening, removing noise, edge detection and texture analysis. Textures can describe a wide variety of natural phenomena with random variations over repeating patterns. Since reproducing the realism of the physical world is a major goal for computer graphics, textures are important for rendering synthetic images and animations. Most applications in computer vision and computer graphics involve the concept of image filtering altering to reduce noise and extract useful image structures. Simple explicit linear translation-invariant (LTI) filters like Gaussian filter, Laplacian filter, and Sobel filter are widely used in image blurring/sharpening, edge detection, and feature extraction. . But in many cases (High resolution images), it may become necessary to incorporate additional information from a given guidance image during the filtering process. Hence, the need for new image filters is growing and Entropy filter, Range filter, Standard Filter have served the purpose to some extent. The Content-based retrieval of image features using Texture Filters (Entropy, Range, Standard Deviation filters) have been carried out. The content based color classification of the images clearly indicates the presence of large and relatively small water patches, higher and lower density green areas corresponding to vegetation, Dry soil, Rocks associated with the images. Further using the ANN techniques and pattern recognition tools the different filter outputs are examined for identifying a suitable filter for satellite imageries.

- Data Analysis:

A Rural scene image obtained from *Indian Remote Sensing satellite* **IRS-2 / LISS- II** *camera having 23 m resolution and image size of 517 x 995x 3 Bytes (1704435 Bytes)* has been subjected to image texture based analysis.

Figure 1 : Original satellite rural image

- The Fuzzy based texture filters: There are   three statistical texture filtering functions are ***STD filter: Calculates the local standard deviation of an image   Range filter:** Calculates the local range of an image **Entropy filter:** Calculates the local entropy of a grayscale image.* The above filtering technique neighborhood around the pixel of interest and calculate the statistic for that neighborhood.
- Standard **Deviation Filter (*STD filter :** The STD filter technique specify defining a neighborhood around the pixel of interest and calculating the statistic for the neighborhood to determine the pixel value in the output image. The **stdfilt** function calculates the standard deviation of all the values in the neighborhood.

The standard deviation of the pixels of neighborhoods is computed as

$$stddev = \sqrt{\frac{\sum(x_i - \overline{x})^2}{r*c - 1}}$$

x_i →   *are the individual pixel values of the input map considered by the filter*

$\overline{x}$ →   *is the mean of the pixel values considered by the filter*

R →   *is the size of the filter in rows*

C →   *is the size of the filter in columns*

For each group of pixels in the input map, a standard deviation filter calculates the standard deviation and assigns this value to the center pixel in the output map.

- **Range** Filter**:** Find local range of image. Range filter is used to find edges within an image and works for only monochrome . In the range method, the color value of each pixel is replaced with the difference of maximum and minimum (i.e. the range) of color values of the pixels in a surrounding region. The **rangefilt** function uses a 3-by-3 neighborhood but you can specify neighborhoods or different shapes and sizes. Determining Pixel Values in Range Filtered Output Image. Range filter technique specifies neighborhoods or different shapes and sizes.
- **Entropy filter**: An entropy filter wherein entropy of a small section of a noted pixel (x, y) is calculated and said noted pixel (x, y) is renewed by an obtained entropy value. Filters image by replacing every value by the information entropy of the values in its range r neighborhood. Using an entropy filter, a smooth portion in image quality is extracted from an original image. The entropy filter technique specifies defining a neighborhood around the pixel of interest and calculating the statistic for the neighborhood to determine the pixel value in the output image. The **entropyfilt** function calculates the entropy of the neighborhood and assigns that value to the output pixel. Note that, by default, the **entropyfilt** function defines a 9-by-9 neighborhood around the pixel of interest. To calculate the entropy of an entire image, use the entropy function.

2. Fuzzy Based Texture Analysis

The Satellite rural image has been subjected filter techniques and fuzzy based texture   analysis for identifying the textures associated with different features present in the rural image. The Figure 2(a) shows the satellite rural image STD filter out put and 2(b) shows the texture image derived using the STD filtered output. It is clearly seen from the figure that most of the features present in the original image are absent in the STD filtered textured image (2b) indicating that the STD filters are not suitable for extracting all the features present in the satellite Rural image.
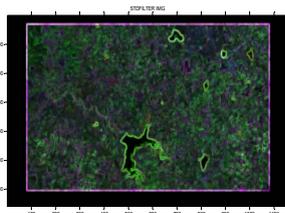
Figure 2(a) : STD filter image of the

satellite rural image

Figure 2(b) : STD filter texture image of the satellite rural image

The satellite rural image was subjected to Range Filter and Fuzzy based texture analysis. The Figure 3(a) and 3(b) shows the Range filter output and texture analysis output. It can be seen from the figure that the foreground pixels have more variability and thus higher range of pixel values indicates sharp boundaries and edges of the rural features. Range filtering makes the edges and contours of the dense regions more visible. The figure also indicate that most of the features present in the original image are absent in the Range filtered textured image indicating that the Range filters are not suitable for extracting all the features form the satellite rural images.
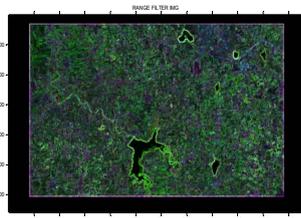

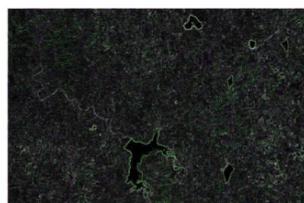Figure 3(a) Range filter texture image of the satellite rural image

Figure 3(b) : Range filter texture image of the satellite rural image

The satellite image is subjected to Entropy filer and Fuzzy based texture analysis. Figure 4(a) shows the filtered out put and Fig 4(b) the texture output of the image. It is clearly evident from the figure that most of the features present in the original satellite image are present in the textured image. The entropy filter output of the image can be used to derive the texture distribution of different features in the image. There is very little variation in the gray-level value. Indicating that the rural features have similar texture and the feature are extended over large regions. It is also seen from the figure that the all the important features present in the rural image such as Vegetation, Water bodies, Dry land and other features like housing etc, show different distinct textures indicating that they are easily distinguishable from one another using the entropy filtered texture analysis.
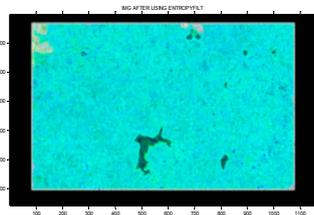

Figure 4(a) : Entropy filter image of the satellite rural image

Figure 4(b) : Entropy filter texture image of the satellite rural image

Further the entropy based techniques indicate that within the observed features variable textures are seen in the images. For example green vegetation indicates the thick vegetation such as forests (Dark green) and thin vegetation due to crops (Light green) in the fields in the textured image. The new features can be well demarked in the textured image and uniquely identified providing further scope for extraction of these features in the satellite rural image.

3. Neural network Analysis

A Neural network consists of many neurons that co-operate to perform the desired function.An **Artificial neural network** *is composed of many artificial neurons that are linked together according to a specific network architecture. The objective of the neural network is to transform the inputs into meaningful outputs.*
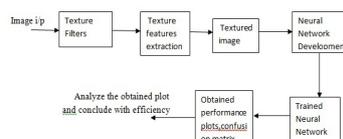

Figure 5. A Block diagram of the Texture Image to Neural network development

Back propagation was created by generalizing the *Widrow-Hoff* learning rule to multiple-layer networks and nonlinear differentiable transfer functions. Input vectors and the corresponding target vectors are used to train a network until it can approximate a function, associate input vectors with specific output vectors, or classify input vectors in an appropriate way as defined by a individual. Standard *back propagation* is a gradient descent algorithm, as is the Window-Hoff learning rule, in which the network weights are moved along the negative of the gradient of the performance function. The term *backpropagation* refers to the manner in which the gradient is computed for nonlinear multilayer networks

There are generally four steps in the training process: (a) Assemble the training data (b) Create the network object (c) Train the network (d) Simulate the network response to new inputs.

The default performance function for feed forward networks is mean square error mse--the average squared error between the network outputs a and the target outputs t. **train** applies the inputs to the new network, calculates the outputs, compares them to the associated targets, and calculates a mean square error. If the error goal is met or if the maximum number of epochs (Each pass through the input vectors is called an *epoch)* is reached, the training is stopped, and train returns the new network and a training record. The error is calculated as the difference between the target output and the network output. The following are notations used in the graph

3.1. ANN performance Analysis:

The result here is reasonable because the train set error, test set error and the validation set error have average similar characteristics, and it doesn't appear that any significant over fitting has occurred. The best validation performance occurs at **iteration n**, and the network at this iteration is returned.

3.2. Training set plot analysis:

One of the problems that occur during neural network training is called over fitting. The error on the training set is driven to a very small value, but when new data is presented to the network the error is large. The network has memorized the training examples, but it has not learned to generalize to new situations. The plot shows the variation of Gradient with respect to Epochs. The gradient is determined using a technique called back propagation, which involves performing computations backward through the network. Validation is used to validate whether the network is generalizing and to stop training before over fitting.

4. Analyzing the Confusion Matrix from the ANN Network

To analyze the ANN network response, the confusion matrix is examined by considering the outputs of the trained network and comparing them to the expected results (targets). Left Diagonal elements =Number of positions that were correctly Classified (e.g. Blue patches classified as Water Bodies). Off Diagonal elements = Number of positions that were misclassified (e.g. Green patches classified as Vegetation Area) . Blue Cells = Total percentage of correctly predicted residues corresponding to water bodies (accuracy of 80-90%).Green Cells = Total percentage of correctly predicted residues corresponding to vegetation (accuracy of 90-100%).Red cells=Total percentage of incorrectly predicted residues. Black cells=Total percentage of cells which could not retrieve any result.
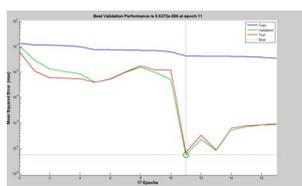
5. STD Filter:

Figure 5(a) : Performance Characteristic graph of the STD filter
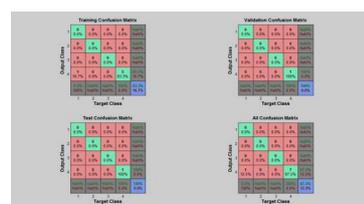

Figure 5(b) Confusion matrix for std filter

The figure 5 (a) shows a plot of the mse Mean square error (mse) and number of epochs for the STD

filtered satellite textured image data. The corresponding confusion matrix for the same data is shown in figure 5 (b). In the figure the blue line represents the performance of the trarined data, the red line corresponds to test data, green line correspomds to the validation and dotted line is for the best performance.. It is evident from the figure 5 (a) that for STD filter the test and validation curves drops slowly with the number of epochs and reaches the best performance for the test and validation data at epoch 11. Further It should be noted from the figure that the test and validation data are not maching with trained data even after the epoch 11.

The figure 5 (b) shows the confusion matrix for the STD filtered textured data. The percentage distribution of output class to the targer class for 5 classes of objects are shown in the confusion matrx as derived for the STD filtered textured data. It is evident from the confusion matrx analysis that the green colour corresponding to vegetation shows maximum distribution with a higher leve of confidence ~83 to100% and the Blue colour for water bodies shows ~12 to 83% The other features are not very significantly seen from the STD filtered output.
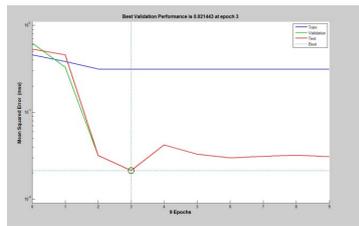
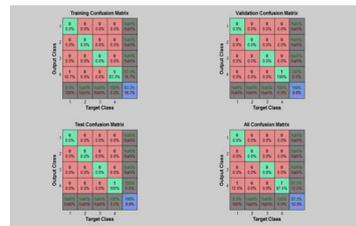## 6. Range Filter

Fig 6(b) Confusion matrix for Range Filter

Figure 6(b) Confusion matrix for range filter

Simarly the figure 6 (a) shows a plot of the Mean square error (mse) and number of epochs for the satellite Range filtered textured data. The corresponding confusion matrix for the same data is shown in figure 6 (b). It is evident from the figure 6(a) that the best and validation curves drops more rapidly with the number of epochs and reaches the best performance for the test and validation data at epoch 3 for the Range filter. Further It may should be noted from the figure that the test and validation data are not maching with trained data even after the epoch 3. The figure 6 (b) shows the confusion matrix for the range filtered textured data.The percentage distribution of output class to the targer class for 5 clases of objects are shown in the confusion matrx as derived for the Range filtered textured data. It is evident from the confusion matrix analysis that the green colour corresponding to vegetation shows maximum distribution with a higher level of occurance ~83 to 100% and the Blue colour representing water bodies shows the level of occurance ~12 to 87% and the Black colour corresponding to other fetures shows the level of occurance ~12 to 87% .The red colour corresponding to soil features are not very significantly seen from the Range filtered output
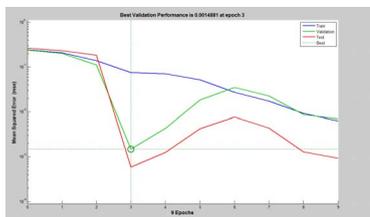
7. Entropy Filter:

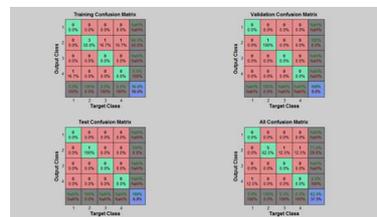Figure 7(a) : Performance Characteristic

graph of the Entropy filter

Figure 7(b) Confusion matrix for entropy filter

Simarly the figure 7 (a) shows a plot of the Mean square error (mse) and number of epochs for the satellite entropy filtered textured data. The corresponding confusion matrix for the same data is shown in figure 7 (b). It is evident from the figure 7(a) that the best and validation curves drops very rapidly with the number of epochs and reaches the best performance for the test and validation data at epoch 3 .for the entropy filter. Further It could be noted from the figure 7(a) that the test and validation performance data

match very close with the trained data after epoch 3. The figure 7(b) shows the confusion matrix for the range filtered textured data. The percentage distribution of output class to the targer class for 5 clases of objects are shown in the confusion matrx as derived for the Range filtered textured data. It is evident from the confusion matrix analysis that the green colour corresponding to vegetation shows maximum distribution with a higher level of occurance ~62 to100% and the Blue colour representing water bodies shows the level of occurance ~37 to 100%   and Black colour corresponding to other fetures such as housing etc the level of occurance ~40 to100%..The red colour corresponding to land features are not very significantly seen from the entropy filtered output. The confusion matrx data for all the three filtered textured satellite rural image is summarised in Table 1. The table illustrates that the best filterd output is seen for the entropy filter for all the three important features such as vegetation, water bodiies and other fetures such as housing. The three features predominatly occuring with higher percentages comapred to that of land features is evident form the table derived from Confusion network and the Nurel Netwok Analysis.

Filters	Vegetation (Green %)	Land region (Red %)	Water bodies (Blue %)	Other Features (Black %)
STD	83.3 - 100	12.5 - 16.5	12.5 - 83.5	12.5 -16.5
Range	83.3 - 100	12.5 - 16.5	12.5 - 87.5	12.5 -87.5
Entropy	62.5 - 100	12.5 -1 6.5	37.5 - 100	40 - 100

Table 1: Summarises the percentage of occurance of the various features present in the satellite rural image.

8. Conclusion

It may be concluded from the analysis carried in the paper that,

1. The range filters are useful for extracting the edges and boundaries present in a satellite rural image.
2. The entropy filter based texture analysis is best suited for extracting the features present in satellite rural image.
3. The Neural network analysis of the entropy filtered texture image is very essential for validating with less number of iterations (epochs), the features present in the satellite images
4. The mse and confusion matrix results indicate that it is possible to accurately estimate the occurrence of various features present in the satellite rural images.
5. The results of the Neural network carried out in this paper demonstrate that the features like vegetation, water bodies and the other features such as housing etc shows higher percentage of occurrence

9. References

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